IBM Quantum, the Midwest, Academic Collaborations

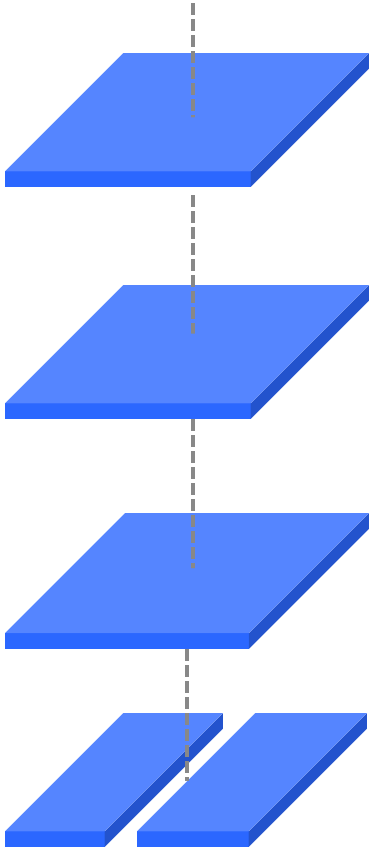
Full Stack Quantum Computing Company

Tools & Services

Integrated utilities that extend functionality through the stack

Algorithms & Applications

Applying quantum circuits and hybrid routines to solve real world problems



Qiskit Functions

Collections of circuits, templates, and pulse schedules across multiple application areas.

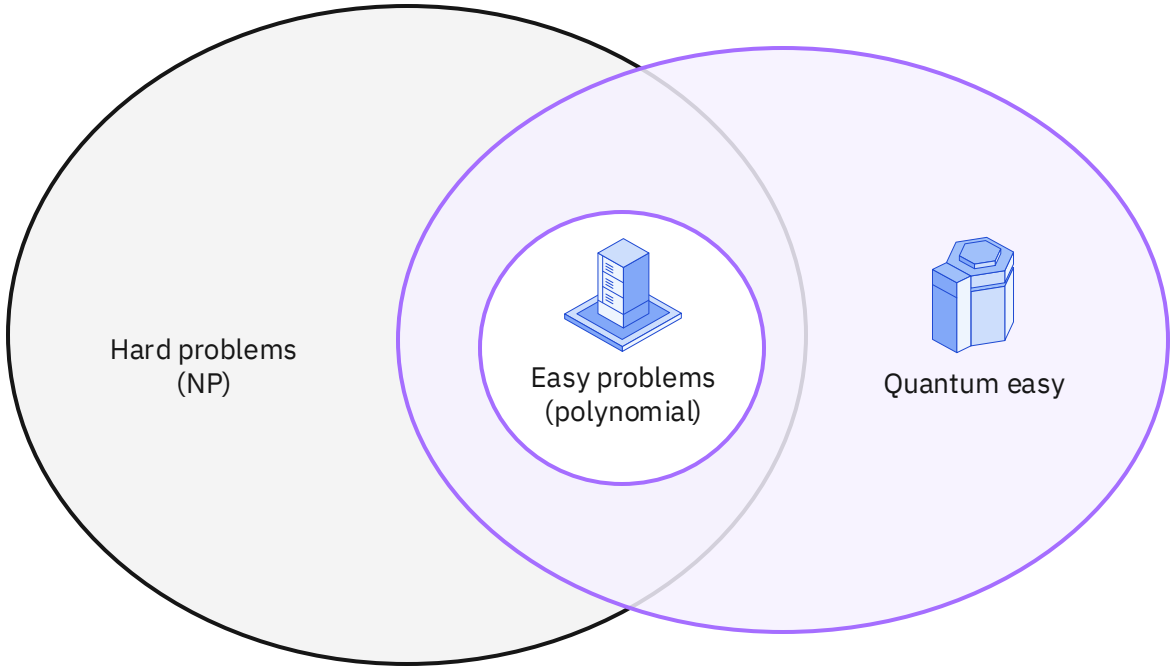
Hardware & Systems

Computing systems capable of running quantum circuits and pulse schedules

The Quantum Computing Stack

There is a rich seam of problems that cannot be solved by classical and supercomputing, and never will.

These are the trillion-dollar problems that quantum computing was designed to solve.



These computationally complex problems exist across almost every industry.

Banking

- Fraud monitoring
- Portfolio optimization
- Risk simulation
- Customer analytics
- Time series forecasting

Automotive

- Battery material design
- Material design
- Mobility as a Service
- Quality control
- Self-driving and ADAS
- Production optimization

Chemicals

- Sustainable products
- Low-carbon manufacturing
- Resilient supply chains
- Process optimization
- Asset health

Life sciences

- Efficient drug research and development
- Clinical trials
- Tractable protein folding
- Call-centric therapeutics
- mRNA

Healthcare

- Accelerated diagnoses
- Personalized interventions
- Adherence to drugs
- Biomarkers
- Image processing

Logistics

- Global logistics optimization
- Disruption management
- Routing optimization
- Predictive maintenance
- Forecasting

Public services

- Security/safety
- Multimodal transport
- City resource planning
- Disaster management
- Fraud detection in tax and social

Insurance

- Catastrophe modeling
- Precise customer profiling
- Efficient risk management
- Optimized pricing of premiums

Electronics

- Faster product design
- Circuit defect identification
- Process optimization
- Production optimization
- Quality control

Airlines

- Forecasting and revenue
- Irregular operations
- Network planning
- Safety and maintenance
- Hyper-personalization

Energy and utilities

- Energy trading
- Optimization of energy grid
- Renewables system design
- Energy forecasting
- Hyper-personalization
- Asset health

Aerospace

- Material discovery
- Aircraft design
- Asset health
- Corrosion and material interaction
- Fuel efficiency

Oil and gas

- Emissions reduction
- Reservoir simulation
- Virtual flow meters
- Subsurface modeling
- Failure prediction

Telecom

- Network optimization
- Network anomaly detection
- Contextual customer segmentation
- Cybersecurity network

Development Roadmap

IBM **Quantum**

	2016–2019 ✓	2020 ✓	2021 ✓	2022 ✓	2023 ✓	2024	2025	2026	2027	2028	2029	2033+
	Run quantum circuits on the IBM Quantum Platform	Release multi-dimensional roadmap publicly with initial aim focused on scaling	Enhancing quantum execution speed by 100x with Qiskit Runtime	Bring dynamic circuits to unlock more computations	Enhancing quantum execution speed by 5x with quantum serverless and Execution modes	Improving quantum circuit quality and speed to allow 5K gates with parametric circuits	Enhancing quantum execution speed and parallelization with partitioning and quantum modularity	Improving quantum circuit quality to allow 7.5K gates	Improving quantum circuit quality to allow 10K gates	Improving quantum circuit quality to allow 15K gates	Improving quantum circuit quality to allow 100M gates	Beyond 2033, quantum-centric supercomputers will include 1000's of logical qubits unlocking the full power of quantum computing
Data Scientist						Platform						
						Qiskit Code Assistant	Qiskit Functions Service	MappingCollection	Specific Libaries			General purpose QC libraries
Researchers					Middleware							
					Qiskit Serverless ✓	Qiskit Transpiler Service	Resource Management	Circuit Knitting x P	Intelligent Orchestration			Circuit libaries
Quantum Physicist			Qiskit Runtime Service									
	IBM Quantum Experience ✓		QASM3 ✓	Dynamic circuits ✓	Execution Modes ✓	Heron (5K)	Flamingo (5K)	Flamingo (7.5K)	Flamingo (10K)	Flamingo (15K)	Starling (100M)	Blue Jay (1B)
						Error Mitigation	Error Mitigation	Error Mitigation	Error Mitigation	Error Mitigation	Error correction	Error correction
						5k gates 133 qubits	5k gates 156 qubits	7.5k gates 156 qubits	10k gates 156 qubits	15k gates 156 qubits	100M gates 200 qubits	1B gates 2000 qubits
						Classical modular	Quantum modular	Quantum modular	Quantum modular	Quantum modular	Error corrected modularity	Error corrected modularity
						133x3 = 399 qubits	156x7 = 1092 qubits	156x7 = 1092 qubits	156x7 = 1092 qubits	156x7 = 1092 qubits		
	Early ✓ Canary 5 qubits; Albatross 16 qubits; Penguin 20 qubits; Prototype 53 qubits	Falcon ✓ Benchmarking 27 qubits		Eagle ✓ Benchmarking 127 qubits								

Innovation Roadmap

Software Innovation	IBM Quantum Experience ✓	Qiskit ✓ Circuit and operator API with compilation to multiple targets	Application modules ✓ Modules for domain specific application and algorithm workflows	Qiskit Runtime ✓ Performance and abstract through Primitives	Qiskit Serverless ✓ Demonstrate concepts of quantum centric-supercomputing	AI enhanced quantum ✓ Prototype demonstrations of AI enhanced circuit transpilation	Resource management System partitioning to enable parallel execution	Scalable circuit knitting Circuit partitioning with classical reconstruction at HPC scale	Error correction decoder Demonstration of a quantum system with real-time error correction decoder			
Hardware Innovation	Early ✓ Canary 5 qubits; Penguin 20 qubits; Albatross 16 qubits; Prototype 53 qubits	Falcon ✓ Demonstrate scaling with I/Orouting with Bump bonds	Hummingbird ✓ Demonstrate scaling with multiplexing readout	Eagle ✓ Demonstrate scaling with MLW and TSV	Osprey ✓ Enabling scaling with high density signaldelivery	Condor ✓ Single system scaling and fridge capacity	Flamingo Demonstrate scaling with modular connectors	Kookaburra Demonstrate scaling with nonlocalc-coupler; Demonstrate path to improved quality with logical memory	Cockatoo Demonstrate path to improved quality with logical communication	Starling Demonstrate path to improved quality with logical gates		
				Egret Tunable coupler demonstration		Heron Architecture based on tunable-couplers	Crossbill m- coupler					

✓ Executed by IBM

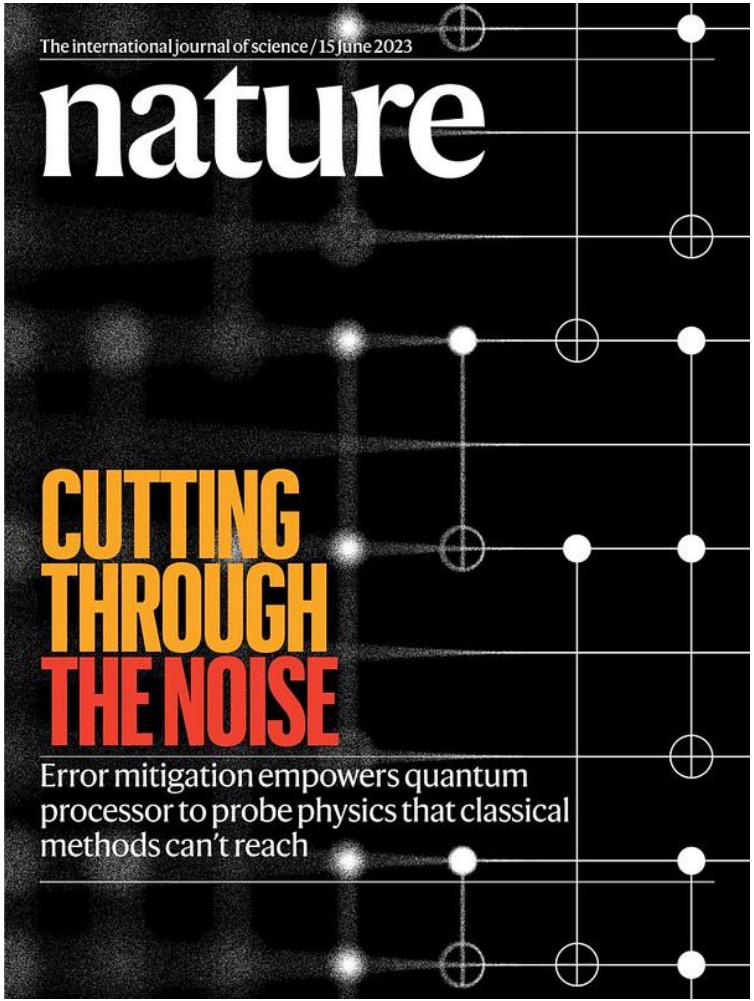
On target

The Gross (144) Code

"In our paper, we looked for fault-tolerant quantum memory with a low qubit overhead, high error threshold, and a large code distance."

A noisy quantum computer produces accurate expectation values on 127 qubits, outside of brute force classical computation.

Y. Kim, A. Eddins, et al, Nature. **618**, 500–505 (2023)



Network members

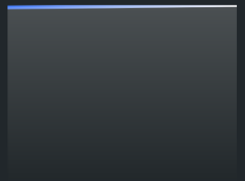
281

Industry clients

54

Registered users

606K



90 days change ↑ 8K (1%)

Quantum innovation centers

39

Content viewers

8.6M

90 days change ↑ 250.3K (3%)

Quantum systems deployed

12

Qiskit forks

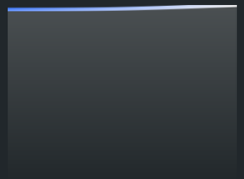
2,242

Qiskit dependent projects

345

Total research papers

2,967



90 days change ↑ 74 (3%)

Certified developers

1,188

Qiskit advocates

544

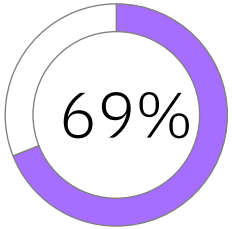
Quantum courses

711

Qiskit

SDK 1.0

Software for performance, stability, and reliability of quantum-centric computations.



The lingua franca of quantum computing preferred by 69% of users*; write once and execute quantum circuits on 10+ different hardware manufacturers

* 2023 Unitary Fund survey

Expanding education and research

IBM Quantum Learning Platform!

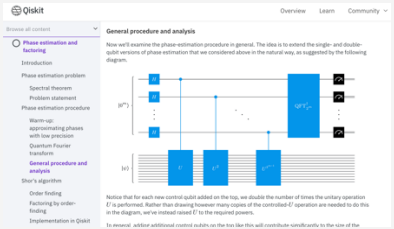
In-depth **quantum education and workforce development** by world renowned experts

Understanding quantum information and computation by John Watrous

Quantum computing courses using Qiskit

710

Online companion textbooks with problem sets and progress tracking, utilizing Qiskit and IBM Quantum hardware

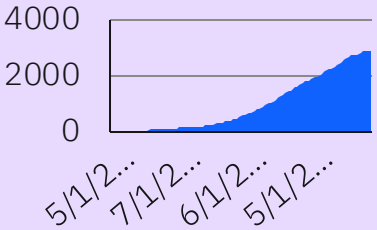


Learners accessing digital content

8.2M+

Science in the era of emergence

Research in this era was heavily focused on characterizing quantum hardware, error mitigation and suppression, and proof-of-concept applications



Published research papers since 2016

2886

Open Quantum Initiative, 2024
In partnership with the Chicago Quantum Exchange

THE UNIVERSITY OF CHICAGO

UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

Northwestern University

PURDUE UNIVERSITY

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

CHICAGO QUANTUM EXCHANGE